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The imprint of carbon combustion on a superburst from the accreting neutron star 4U 1636-536

Keek L., Cumming A., Wolf Z., Ballantyne D., Suleimanov V., Kuulkers E., Strohmayer T.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2015 The Authors. Published by Oxford University Press on behalf of the Royal Astronomical Society. Superbursts are hours-long X-ray flares attributed to the thermonuclear runaway burning of carbon-rich material in the envelope of accreting neutron stars. By studying the details of the X-ray light curve, properties of carbon combustion can be determined. In particular, we show that the shape of the rise of the light curve is set by the slope of the temperature profile left behind by the carbon flame. We analyse Rossi X-ray Timing Explorer/Proportional Counter Array observations of 4U 1636-536 and separate the direct neutron star emission from evolving photoionized reflection and persistent spectral components. This procedure results in the highest quality light curve ever produced for the superburst rise and peak, and interesting behaviour is found in the tail. The rising light curve between 100 and 1000 s is inconsistent with the idea that the fuel burned locally and instantaneously everywhere, as assumed in some previous models. By fitting improved cooling models, we measure for the first time the radial temperature profile of the superbursting layer.We find d ln T/d ln P ≈ 1/4. Furthermore, 20 per cent of the fuel may be left unburned. This gives a new constraint on models of carbon burning and propagation in superbursts.

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Keywords

Accretion, Accretion discs, Stars: individual: 4U 1636-536, Stars: neutron, X-rays: binaries, X-rays: bursts